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THE POSSIBILITIES OF WATER DEVELOPMENT ON THE WESTERN UTAH DESERT AND ITS RELATION TO RANGE MANAGEMENT OF THE AREA

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(Submitted as part of Junior Range Examiner Examination)

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GENERAL DISCUSSION

Water facilities on grazing land play a very important role in the economic development of the State of Utah. Out of a total of fifty-two and a half million acres of land in the State, only 3.5 per cent can be successfully cultivated, and the balance must be used primarily for grazing. (13)° Livestock raising, the third largest industry of the State, depends largely on the grazing resources of the desert land used mainly for winter sheep range. It is obvious, therefore, that, if this wide expanse of desert range is to make its maximum contribution to the economic welfare of the State, adequate water facilities are of the utmost importance. This discussion, then, will show the possibilities of water development and its relation to range management on the Western Utah Desert.

The area in Utah under discussion includes approximately 16,000 square miles lying south of the Great Salt Lake Desert and Great Salt Lake, and located principally in Tooele, Juab, Millard, Beaver, and Iron Counties. °° This land is practically all public, wholly outside of the Railroad Grant tracts and contains a negligible amount of private land in comparison with the total area.

The flora is such as is common to arid regions. The chief shrub cover consists of *Atriplex confertifolia*, *Chrysothamnus spp.*, *Artemisia spp.*, *Eurotia lanata*, *Artemisia nova*, *Sarcobatus vermiculatus*, *Tetradymia spinosa* and *Ephedra viridis.* Utah Juniper and Pinon Pine occur at higher elevations, and occasionally on the bench lands. The herbaceous cover consists primarily of *Hilaria jamesii*, *Oryzopsis hymenoides*, *Boutelous gracilis*, *Sitanion hystrix*, *Distichlis spicata*, and *Sporobolus airoides* on the bench lands and lower valleys, while *Agropyron spp.*, *Poa spp.*, and *Oryzopsis hymenoides* extend to the foothills and mountain slopes.

The principal class of livestock grazed is sheep. Due to scarcity of water and competition with the sheep, cattle grazing is very limited. Approximately 1,000,000 sheep, coming from Utah, southern and southeastern Idaho, Wyoming, and Nevada, use the range at some time during the year.

On a carrying capacity basis, the area has averaged about 1 sheep to 20 acres. This rate of stocking probably would not have resulted in range injury if some control had been exercised as to periods of use, methods of handling, and distribution, together with reasonable and necessary water development. (1) This control, however, has not been exercised, and serious range depletion has followed, particularly in all vicinities where water is available for livestock in the spring and fall when there is no snow. Stockmen acquainted with the area agree that the carrying capacity is much less now than it was forty to fifty years ago.

PRESENT WATERING FACILITIES

There is little running water over the entire area. The Sevier River extends through the eastern portion of Millard County, but is not so located that it can be extensively used for livestock watering purposes. In most parts of this region watering places of any sort are so scarce that large areas are accessible for grazing only in the winter when sheep can use snow for their water supply.

°Numbers refer to references listed at the end of this report.
°° Consult map at end of this report.

Practically every small spring with sufficient flow to provide for a band of sheep has been developed. Storage tanks have been installed, and a few wells have been driven. When the extreme high prices for sheep prevailed, hauling of water - by truck, and by railroad tanks were possible - was adopted to a limited extent. Shallow stock wells have been dug in various parts of the region, but these often dry up when they are most needed. Also a few stock ponds, that are usable for short periods, have been developed for storing water from freshet run-off. However, these facilities are so few and so scattered that satisfactory distribution of stock is not possible.

NEEDS FOR ADDITIONAL WATER

Dr. Stewart states:

> "Too often the lack of water has led the uninitiated to deem the absence of grazing animals a good indication that there is nothing for them to eat; as a matter of fact, it is merely that there is nothing for them to drink and not because the plants are unadapted to grazing."(14)

Additional stock watering facilities are imperative if the best management of the range is to be accomplished. Much of the overgrazing and excessive trailing occur around existing watering places could be largely overcome, more even utilization secured, better seasonal use of ranges adapted for spring, fall, and winter range accomplished, and rehibilation secured for areas now depleted because of misuse if a well distributed system of water developments were available.

This would not only make the area more productive, but would also improve the condition of the livestock and secure increased wool, lamb, and beef production. Losses from poisonous plants and malnutrition would be decreased. Better water facilities and forage during the bucking season would result in better breeding and increased lamb crop. Better distribution could be accomplished and the assignment of individuals and communities to specific localities would be practical. A definite unit of range for the individual operator would make provision of supplemental feeds and other needed facilities to meet winter hazards practical. Under existing conditions, such provision is difficult, if at all possible.

POSSIBILITIES OF FURTHER WATER DEVELOPMENT

During the Miocene epoch, of the Tertiary period, great faulting occurred in this region, breaking up the topography into basins and plateaus. Since this deformation, weathering and disintegration have occurred, while wind and torrential streams have carried sediments out into the basins; hence the serrate peaks, canyons, smooth alluvial slopes, and desert plains underlain by the thick deposits of sand, gravel, and clay. (9) Later, during the Pleistocene epoch, the greater part of this area was covered by Lake Bonneville which deposited more unconsolidated sediments in the basins, particularly out on the flats.

Since these sediments are considered the most valuable water carrying beds, there are all indications of the presence of under-ground water in these valleys and desert tracts, provided there is a source of supply. The source of supply comes from rain and snow deposited on the numerous mountains of this region, most of which are of 7,000 to 12,000 foot elevation. [o] No precipitation records for these ranges

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[o] See map at end of this report.

have been kept, but the character of their vegetation gives evidence of a greater precipitation than on the lowlands where there is a varying precipitation of from 4.85 inches to 26.12 inches annually. It is evident, therefore, that there is a supply of water in these unconsolidated sediments. This supply is further evident by the fact that there is no outlet for the water of this region.

Director William Peterson (11) thinks that there is a possibility of sufficient underground water in the desert valleys of this region to provide adequate stock water at reasonably frequent intervals. Dr. O. E. Meinzer suggests that

> "In some of these sections an intelligent search would probably discover ground water supplies which would increase greatly the value of the range;" (4)

while Dr. Frederick J. Pack adds that

> "There is undoubtedly a very large underground water supply in this region of good quality and easily accessible." (10)

At Las Vegas, Nevada, bordering this region on the southwest a survey was made for water. A pipe eight inches in diameter was sunk producing a flow rising thirty inches above the surface. Further evidence of water is shown by the wells along the Salt Lake & Los Angeles Railroad, which runs diagonally across the region.[o]

A typical valley of this region consists of a rock trough partly filled with unconsolidated sediments forming alluvial slopes on either side with a central flat between. Stream deposits underlie the alluvial slopes while lake deposits may occur at the center. As new supplies of water are poured out from the mountains and absorbed by porous gravel of alluvial slopes, the amount of ground water is increased and some of it returns to the surface in the lowest parts of the central flats - either as springs or by imperceptible capillary action - and is removed by evaporation. Thus the water level is near the surface on the central flats and lower parts of the alluvial slopes and is easily available by sinking wells into the unconsolidated sediments. (5)

> "The most favorable location for wells is at the base of an alluvial slope where the surface is not far above the groundwater level but where coarse water-bearing beds are still plentiful, on the side of the valley bordered by the mountains which furnish the most water, and in the vicinity of the largest streams."[oo] (6)

The deserts are also surrounded by alluvial slopes descending from the upland borders, but differ from the valleys inthat they have more extehsive flats with more lake deposits. The base of these alluvial slopes is like that of the valleys, but the flats differ in being underlain more largely by non-water-bearing clay and quicksand and beds that make the water salty. (7)

Generally the quality of the water in the valleys is good, although some of the water is slightly charged with sodium salts. In the desert valleys, good water borders the alluvial slopes, while in the interior much is saline in the upper beds. In the lower beds, however, good water is obtainable.

Following are prospects for underground water in the valleys and desert flats

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[o]Consult Tables 1,2,3,4,5,6,7, and 8 at end of this report.
[oo]See Plate 1 at end of this report.

in this region, according to the United States Geological Survey.[o]

TOOELE AND RUSH VALLEYS

Wells could be sunk in the water-bearing beds for good water. At upper end and middle parts of slopes water lies rather deep. Also rocks and boulders would occur, but by the use of heavy machinery drilling could penetrate them. [oo]

SKULL VALLEY

Good water can be obtained on lower slopes bordering the Onaqui Mountains.

The water level is probably deep in part of the valley and in porous sand area long Barlow Creek. The lower slopes north of Reynolds Pass offer the best prospects. Heavy machinery would be practical.

JUAB VALLEY

Water that sinks on upper gravelly slopes reappears in low wet areas along central axis of the valley. This water could be utilized by wells before it reaches the central axis. Wells could also be drilled on higher ground and pumps installed.

SAGE VALLEY

Water could be obtained by wells near south end where surface is low and sediments deep. Farther north water prospects uncertain.

DOG AND FERNOW VALLEYS

A 75 foot hole and a 230 foot state well proved unsuccessful.

TINTIC VALLEY

Wells, at moderate depths producing water of good quality, could be successful in lower part of the valley. Most places limestone and quartzite formation dip away from valley and make water prospects unfavorable.

OLD RIVER BED AND CHERRY CREEK REGION

Good prospects for obtaining successful wells with good quality of water are in the region lying south west of Rockwell's ranch, Valley north of Desert Mountain, below Provo shore line, and the old river bed east of McDowell Mountains.

Water on low flats east of lava plateau may be saline.

DRUM AND SWASEY WASH REGION

Possibilities are at foot of slope from House Range and in areas where valleys merge into low flat of Sevier Desert.

No water on flats except at great depths.

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[o]The information of the valleys is statistical and factual with no intention of presenting the material on par with the rest of this report.

[oo]See plate 1 at end of report.

WAH WAH VALLEY

Conditions not favorable for finding ground water in this region. May be at great depth on flanking slopes and in small supplies in basins lined with igneous rocks, but chances are poor.

SEVIER LAKE BOTTOMS

Sediments meager in quantity and fine grained, hence prospects are unpromising.

Possibilities on alluvial slopes heading larger canyons where most gravel and water have come.

WHITE VALLEY

This valley, 300 to 500 feet below the water level in Snake Valley, indicates by the group of springs that it has accumulated water in the sediments below the central flat.

Prospects are better at foot of slopes where material is coarser and less impregnated with alkali.

South appendage of valley has low altitude and may have ground water at moderate depths. Most of the steep east slopes lie so high above the flat that their ground water is inaccessible or drained away.

FISH SPRINGS VALLEY

Best prospects are at base of slopes near margin of the central flat, and in the mountains where igenous rocks occur.

Beneath flat, water may be poor in quality, and may also be fine grain lake deposits.

SNAKE VALLEY

Burbank:- Good artesian water could be had at Lake Creek above reservoir where level is 9 to 18 feet and could be made available for irrigation by a small pump. Prospects are good in lower part of White Sage Valley, but middle and upper part the level is too far below the surface.

Garrison:- Depth to water decreases toward the north.

Between Garrison and Conger's Ranch:- Water would be found in low tract traversed by Baker Creek. Above the 5,000 contour, in the large valley east of Snake Valley, chances of obtaining wells at moderate depths and with supplies large enough for stock are reasonable.

Between Conger's Ranch and Trout Creek:- Entire stretch is saturated with water near the surface along the axis of the valley. Wells, with water of good quality can be obtained on the central flat and near foot of the alluvial slopes, especially on west side.

PLEASANT VALLEY

Several wells occur, but attempt for flows have been unsuccessful.

Trout Creek to Calloo:- Good supplies can be obtained at moderate depths in lower parts of valley, especially on the west side that receives large contributions.

Calloo:- The water level is near the surface at Willow Springs. Toward the west the flowing area is limited by the rise in the surface of the land. Flows have been struck 2 miles east of Kearney's Ranch buildings.

Between Calloo and Fish Springs:- The water level and surface nearly coincide, yet prodpects for satisfactory wells are not good because sediments are too fine and water salty. In general the prospects get poorer as the distance increases from Deep Creek Range.

PAROWAN VALLEY

Best prospects are on lower and middle parts of alluvial slopes, and a belt 16 miles long extending from a point 1 mile northeast of Buckhorn Spring to a point several miles west of Parowan. No prospects for securing flows on higher levels of alluvial slopes.

RUSH LAKE VALLEY

Both north and south basins have possibilities of further development of water in the unconsolidated deposits. Deeper wells could be drilled where shallow wells now occur. Pumps could be used to advantage.

ESCALANTE DESERT

Ground water is near the surface on the low flats.

Vicinity of Lund:- Water level nearly coincides with surface at Lund, west of Lund, to Sulphur Spring, north, northeast, east, and southeast of Lund for some miles. Beyond Webster's Spring to T. 35 S., R. 16 W.

Between Lund and Modena:- Level is at moderate depths between Lund and Beryl, and probably between Beryl and a point some distance southwest of Norton. From the railroad west to mountains the depth increases and near mountains may be impracticable to get wells.

Southeast of Modena:- East and southeast of Modena a tract of fertile land occurs in which wells can be obtained, except near rock ridges.

North of Enterprise:- Water can be obtained at moderate depths on bench east of ridge extending northward from Enterprise.

Vicinity of New Castle:- The water level is 80 feet below surface near middle of line between T 36 S and T 35 S in R 15 W and North East 1/4 Sec 7, T 36 S, R 15 W; also 30 feet in sec. 31 T 35 S, R 15 W.

Eastern part of Desert:- Water level occurs at moderate depths in the low lying areas, and at a great distance on the higher benches.

BEAVER BASIN

Very favorable for underground water development.

Water occurs under sufficient pressure in both Beaver Lake and Lake Bonneville beds to produce flowing wells.

"It is reasonably certain that enough water for stock raising purposes could be obtained throughout Escalante Desert to make useful in this way a large territory that is now practically unproductive." (3)

KINDS OF DEVELOPMENTS

The most feasible method of developing stock water on the area is the improving of all existing natural water supplies. Springs should be cleared and enclosed to protect them from damage by wild horses and straying stock. Where dug wells or seeps occur, they could be made more valuable and stable by being dug deeper and adequate storage facilities provided. By having larger pipes with the casing perforated at each water level, the drilled wells could produce larger supplies.

Where areas are devoid of springs or running streams, or where such waters are insufficient, wells or storm-water reservoirs and occasionally pipe lines from springs, wells, or tanks must be resorted to.

Wells could be made the mainstay of the livestock watering system in this area. They are less likely to fail in time of need, provide water more nearly where needed, and usually provide better water. (16) Due to the lack of abundance of head water and pressure, pumping would be necessary in the majority of the wells in this region. These pumping wells would have to be supplied with power, either gas engine or wind, and also with a place for storage of the water.°

Where the cost of wells is excessive, the chances for a flow doubtful, and where springs are absent, dams and reservoirs are often practical. The nature of the soil surface in this region makes it possible to construct reservoirs and dams on select sites, where the water supply is adequate. The cost would vary with the kind and size of the reservoirs. A recent survey of the Forest Service, based on 592 surface reservoirs on the ranges of ten national forests in Arizona and New Mexico, shows an average cost of $695, with extremes of $20 and $15,000. (17) On national forests in Utah and Nevada reservoirs and stock ponds have been constructed at costs ranging from $75 to $300.

In regions remote from any form of water and where indications of ground water are lacking, piping and hauling of water is sometimes practical. The cost of such practices varies according to the method and extent of development and distance of hauling. On the Jornada Range Reserve in southern New Mexico, water from three springs was piped nine miles across a portion of range formerly unused and unwatered. Small tanks or troughs were installed at intervals of two miles. The cost of this was $710 a mile. (18) On the Deschutes and Ochoco Forest in central Oregon, water was hauled by trucks of 450 gallons capacity. The distance varied from 4 to 29 miles, averaging eight miles. The average cost over a 16 year period was 18 cents per head per month. °° (2) At United States Sheep Experiment Station, Duboid, Idaho, water was hauled three miles for sheep at 1/4 cent per head per day. Water was also pumped from a deep well (750 ft.) and hauled three miles at 1/3 cent per day, per head. (12)

All these undertakings were considered good investments since water is essential if the forage is to be usable. In the Utah region these methods could also be applied, at least in modified form, depending on the character of the range and existing need for water, providing control of the area were such as to justify the expense.

°°This water was also used to fight fire.

°For costs consult table No. 7 at end of this report.

The greatest deterent in the application of intelligent range management, including water development, in this region has been the lack of organized control. The stockmen have recognized the need for additional water development, even, in some cases, to the extent of expending large sums of money for development without assurance of protection in their enterprise. Practically the entire area is open public range, without any form of control; consequently there is no inducement for the stockman to incur expenses for development, unless he can be protected against the encroachment of others.

Proper water development for the area, as a whole, is not likely to go forward until some form of permanent control is established.

CONCLUSIONS

1. The desert ranges of Utah constitute an important link in the permanent economic welfare of the State.

2. These ranges are deteriorating, largely due to the lack of adequate water facilities for stock watering purposes, causing overgrazing and an uneven utilization of forage.

3. Water for livestock purposes occurs at very infrequent intervals throughout this region.

4. Sufficient water is available to justify the development of underground and surface water, in the form of wells and stock ponds, at sufficiently frequent intervals to provide a fair water supply over practically the entire area at reasonable cost.

5. Water development on a scale adequate to meet the needs is not feasible until some system of organized range control is in effect which will safeguard the investments of individuals, communities, or other agencies that might undertake such development.

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE RAILROAD
12-INCH WELL, MILFORD

	Thickness Feet	Depth Feet
Soil	4	4
Sand	6	10
Blue Clay	22	32
Sand	33	65
Blue clay	10	75
Sand and gravel	15	90
Blue clay	25	15
Hardpan	4	119
Quicksand	35	154
Blue clay	15	169
Sand (artesian flow)	81	255
Red clay	10	265
Quicksand	5	270
Sand	5	270
Clay	8	278
Sand	10	288
Yellow clay	17	305
Cemented gravel	5	310

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE RAILROAD WELL
AT BERYL

	Thickness Feet	Depth Feet
Soil	8	8
Clay and gravel	8	16
Gravel (water bearing)	7	23
Gravel and clay	15	38
Clay	80	118
Clay and gravel	57	175
Gravel (water-bearing)	5	180
Clay	20	200
Sand (water-bearing)	3	203
Clay	5	208

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE
RAILROAD WELL AT LUND

	Thickness Feet	Depth Feet
Sand	2	2
Clay	4	6
Gravel (small flow)	6	12
Coarse gravel	4	16
Hardpan and clay	49	65
Quicksand	4	69
Blue Clay	80	149
Sand	4	153
Red clay	12	165
Blue clay	159	324
Red rock	6	330
Blue clay	70	400
Quicksand	20	420
Green shale rock	10	430
Clay and sand	10	440
Sand (small flow)	3	443
Blue clay	11	454
Clay and sand	8	462
Sand (large flow)	13	475
Clay	3	478
Sand	6	484
Red clay	2	486
Very fine sand	8	494
Red clay	10	504
Dark clay	4	508
Blue clay	14	522
Very fine sand	3	525
Blue clay	2	527
Fine sand (small flow)	3	530
Brown clay	19	549
Sand	1	550
Brown clay	23	573
Coarse sand	10	583
Coarse gravel (large flow)	2	585
Blue clay	—	—

TABLE IV

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE RAILROAD WELL AT THERMO

	Thickness Feet	Depth Feet
Soil	5	5
Fine Gravel	5	10
Red sand	3	13
White clay	25	38
Fine gravel (water-bearing)	3	41
White clay	54	95
Red clay	45	140
Quicksand	27	167
Red clay	13	180
Sand and clay	25	205
Blue clay	20	225
Sand	10	235
Clay	9	244
Clay and gravel	31	275
Clay and sand	41	316
Clay and gravel	12	328
Sand	13	341
Clay and gravel (water-bearing)	60	401

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE
RAILROAD WELL AT OASIS

	Thickness Feet	Depth Feet
Soil	8	8
Sand	3	11
Blue clay	49	50
Sand	10	60
Lime & shells	20	80
Quicksand	45	125
Blue clay	40	165
Sand	5	170
Blue clay	20	190
Red clay	45	335
Sand	15	350
Blue clay	20	370
Red clay	25	395
Sand	13	408
Sandstone	4	412
Blue clay	68	480
Sand	11	491
Red clay	9	500
Blue clay	27	527
Quicksand	3	530
Clay and sand	29	559
Black sand	3	562
Clay and gravel	13	575
Clay	23	598
Cemented gravel	12	610
Soft sandstone	7	617
Clay	6	623
Rock	2	625
Clay	15	640
White clay	16	656

Water under pressure sufficient cause it to flow at the surface was encountered at ten different horizons. Pumped 200 gal. per minute. Drinking water comes from a depth of 350 ft. It produces 30 gal. per minute.

RECORD OF THE SAN PEDRO, LOS ANGELES AND SALT LAKE
RAILROAD WELL AT LYNN

	Thickness Feet	Depth Feet
Clay	8	8
Gravel	10	18
Sand	12	30
Sand and gravel	10	40
Sand	20	60
Blue clay	95	155
Blue sandy clay, water-bearing	60	215
Sand	10	225
Coarse gravel, water-bearing	10	235

12-inch pipe. Pumped at the rate of 90 gal. per minute

SECTION OF RAILROAD WELL AT GOSS

	Thickness Feet	Depth Feet
Clay	12	12
Clay and gravel	25	37
Sticky blue clay	32	69
Clay	118	187
Blue waxy clay & brown sedimentary sand (salty water 195 ft., 1 gal. per minute.)	15	202
Blue clay	24	226
Blue clay and shale	18	244
Blue shale	60	304
Blue clay	46	350
Fine sand (salty water; 14 gal. per min.	5	355
Gray shale	59	414
Soapstone	238	652
Brown waxy clay	96	748
White clay	15	763
Hard blue clay	93	856
Hard soapstone	17	873
Blue clay	347	1220
Silt shale	42	1262
Brown clay	38	1300
Brown clay and rock	12	1312
Rock	10	1322
Sedimentary stone	12	1334
Silt shale	48	1382
Shale	49	1431
Soapstone	83	1514
Soapstone and boulders	26	1540
Soapstone	44	1584
Cemented gravel	17	1601
Blue limestone	4	1605
Cemented gravel	5	1610
Blue limestone	22	1632
Blue limestone & yellow clay mixed	11	1643
Granite (a soft streak between 1,770 and 1,773 ft. is supposed to be the source of the large supply of water)	132	1775

RECORD OF RAILROAD WELL AT TOPLIF, UTAH

	Thickness Feet	Depth Feet
Yellow clay	—	10
Yellow clay and gravel	10	20
Yellow clay and boulders	106	126
Clay, gravel, and sand	78	204
Limestone fragments and clay	11	215
Limestone, broken	10	225
Limestone quartzite, solid	10	235
" " , and yellow clay	40	275
Lime Quartzite, honeycombed	38	313
" " , solid	49	362
" " , crevices	32	390
" " , solid	3	393
" " , and porphyry	43	436
" " ,	30	566
" " , & porphyry, water-bearing	19	585
Lime quartz; crevices filled with water, stratified	13	598
	—	654

TABLE NO. 7. COST OF 12 TYPICAL DRILLED-WELL PUMPING PLANTS ON ARIZONA AND NEW MEXICO RANGES

Equipment	1	2	3	4	5	6	7	8	9	10	11	12
Well:												
Depth (ft.)	840	740	600	400	720	351	430	284	330	350	49	90
Drilling cost ($)	3,600	3,000	2,550	2,500	3,000	704	645	412	442	457	200	200
Casing :												
Length (ft.)	830	740	600	400	720	350	381	265	10	210	10	90
Diameter (in.)	6-7/8	6-7/8	6-5/8	6-5/8	6-5/8	*---	6-1/4	6-1/4	6	4-1/4	6	6
Cost ($)	1,330	1,110	900	600	1,080	295	476	331	11	157	11	150
Pipe:												
Length (ft.)	820	740	600	400	720	350	360	225	320	265	45	90
Diameter (in.)	3	3	2-1/2	2-1/2	2	2-1/2	3	3	3	3	2	2-1/2
Cost ($)	820	740	600	400	540	125	216	135	116	159	(1)	(1)
Cylinder:												
Length (ft.)	8	8	3	3	3	--	3	2	--	2	--	--
Cost ($)	100	100	25	25	25	15	50	38	15	38	(1)	(1)
Rod:												
Size (in.)	2-1/4	2-1/4	1-3/4	1-7/8	1-3/4	1	1-3/4	1-3/4	1	1-3/4	1-1/2	1-1/2
Cost ($)	615	480	540	350	470	68	97	61	60	71	74	75
Mill:												
Kind	Wood	---	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Diameter (ft.)	25	---	20	18	18	16	16	12	16	12	12	12
Cost ($)	600	---	600	450	450	308	546	250	308	250	200	150
Tower:												
Kind	Wood	Wood	Wood	Wood	Wood	Wood	Steel	Steel	Wood	Steel	Wood	Wood
Cost ($)	400	150	250	350	300	84	(2)	(2)	94	(2)	105	105
Gas engine, tools, etc.												
Horsepower	12	16	10			4						
Cost ($)	600	850	400			300						
Storage:												
Size (ft.)	'55	'46	40:70	'46	3,300	'30	--	---	'30	--	'30	'30
Depth (ft.)	5	5	7	5	--	2	--	--	2	--	2	1-1/2
Kind	Steel	Steel	Conc.	Steel	Steel	Steel	--	--	Steel	--	Mason	Steel
Cost ($)	3,000	2,000	2,000	2,000	300	300	--	--	322	--	322	320
Cost of pump jack ($)	100	100	100	--	--	95	--	--	--	--	95	---
Cost of labor, troughs and miscellaneous ($)	600	500	500	520	500	183	350	350	125	350	153	100
Date of completion	1917	1913	1918	1917	1917	1920	1919	1919	1920	1919	1920	1918
Total costs ($)	11,765	9,030	8,465	7,195	6,665	2,477	2,380	1,577	1,493	1,482	1,160	1,100

1- Pipe and cylinder rod costs grouped Included under "Rod"

2- Included under "Mill". 'Diameter 4-Gallons

3- Taken from Bulletin No. 1358. Range Watering places in the Southwest - M. W. Talbot

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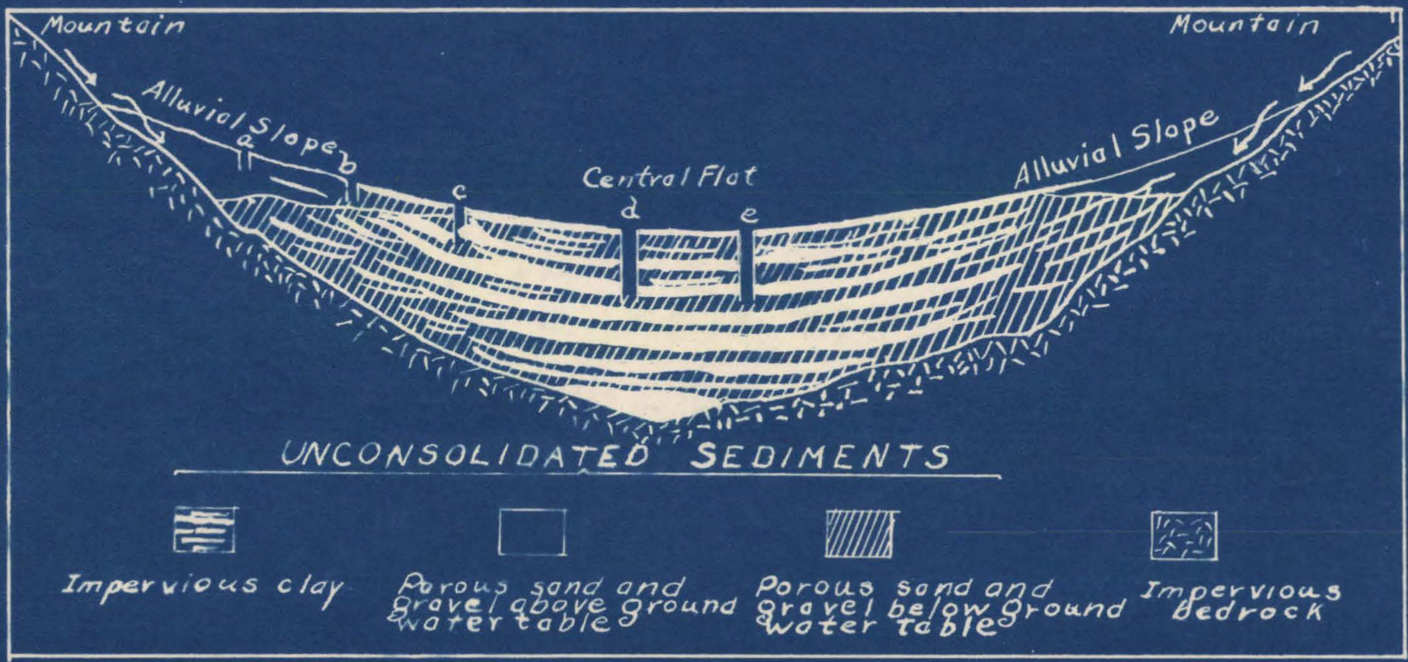

PLATE I.--Diagrammatic cross section of a typical valley, showing ground-water conditions: (a) Dry hole which if sunk deeper would strike bed rock without finding water. (b) Dry hole which would find water if sunk deeper. (c) Pump well of moderate depth. (d) Strong flowing well. (e) Weak flowing well. (Followed figure 5. in Water Supply Paper 277)